Annual Project Summary

Geophysical and Paleoseismic Investigation of the North Farrenburg Lineament: Deformation associated with the New Madrid North fault? Farrenburg, Missouri

Award #99-HQ-GR-0096

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INVESTIGATIONS UNDERTAKEN

This is a two-year investigation to evaluate the origin of Sikeston Ridge and potential seismogenic structures associated with the ridge. For the first year of study, we evaluated the origin of Sikeston Ridge by producing a preliminary surficial geologic map using aerial photography, LANDSAT images, and digital electronic maps. Following preparation of the surficial geologic map, we performed field reconnaissance to characterize potential neotectonic features and to identify locations for additional subsurface investigation that could provide information on the origin of the ridge margins (First-year; Baldwin et al., 2000), and other potential seismogenic sources, such as the

inferred New Madrid North fault (Second-year; this study). The New Madrid north fault is believed to cross the southern part of the ridge from southwest to northeast, and is delineated and inferred only by the northernmost alignment of the northeast-trending contemporary microseismicity of the NMSZ (Johnston and Schweig, 1996; Figure 1).

Mapping conducted during the first year of study identified at least two prominent northeast trending lineaments (herein referred to as the North and South Farrenburg lineaments) near Farrenburg, Missouri (Figures 2 and 3). The trends of these lineaments are unique to the predominant south to southeast-flowing Pleistocene paleo-drainages of Sikeston Ridge (Figure 3). The 3- to 3.5-km-long, N30°E-trending North Farrenburg lineament is coincident with several Pleistocene paleo-drainages that show apparent right-lateral deflection, southeast-facing scarplets, and a northeast-trending topographic depression. The 3-km-long, N25°E-trending South Farrenburg lineament is delineated based on the presence of apparent offset drainages, tonal contrasts, and soil variations. On the basis that the lineaments align partly with a northeast-trending band of microseismicity (uncorrected surface projection), and previously inferred locations of the New Madrid North fault, we hypothesize that the lineaments are associated with an unidentified surface trace of the presumed right-lateral strike-slip New Madrid North fault (Johnston and Schweig, 1996).

In this second year of study, we evaluated the origin of the North Farrenburg lineament, its possible association with the inferred New Madrid North fault, and its implications for seismic hazards assessments in the New Madrid seismic zone (NMSZ). Our investigation included preliminary compilation of unpublished and published geologic and geophysical data collected across the lineament, three shallow seismic reflection profiles, excavation of four paleoseismic trenches and aerial reconnaissance.

RESULTS

Preliminary compilation of subsurface data

Review of limited borehole data compiled across the southern part of Sikeston Ridge shows that there is a thickness change of about 15 m from north to south of post-Tertiary alluvial deposits beneath and east of Sikeston Ridge (Obermeier, 1989). The prominent thickness change is defined as a 35-km-long N30-35°E-trending lineament that begins near Lilbourn and projects to the eastern margin of Sikeston Ridge through Farrenburg. At the eastern margin, the lineament steps left (north) about 5 km and projects northeast along a more northeasterly trend to Bertrand, Missouri (Figure 4). The isopach lineament is aligned in part with a northeast-trending band of seismicity, geomorphic lineaments mapped on Sikeston Ridge (North and South Farrenburg lineaments), and deformation observed in unpublished and proprietary (oil exploration) seismic profiles acquired along a north-south transect across the ridge.

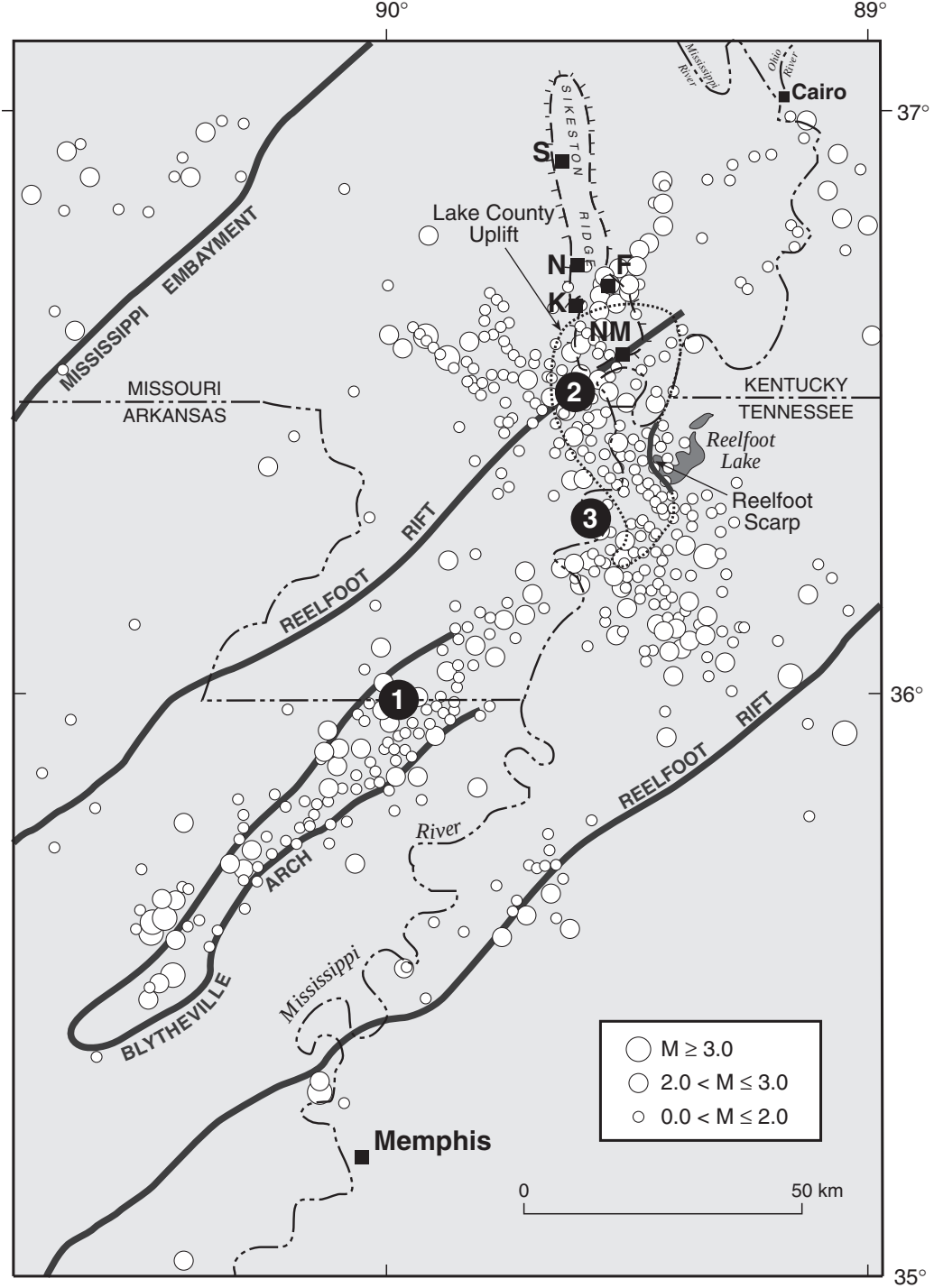


Figure 1. Map showing regional tectonic setting and historical seismicity of the New Madrid seismic zone. F= Farrenburg; S=Sikeston, NM=New Madrid, K=Kewanee, N=Noxall. Solid circles are approximate epicenters for earthquakes on (1) December 16, 1811, (2) February 7, 1812 and (3) January 23, 1812 [After Nuttli, 1973; Johnston and Schweig, 1996].

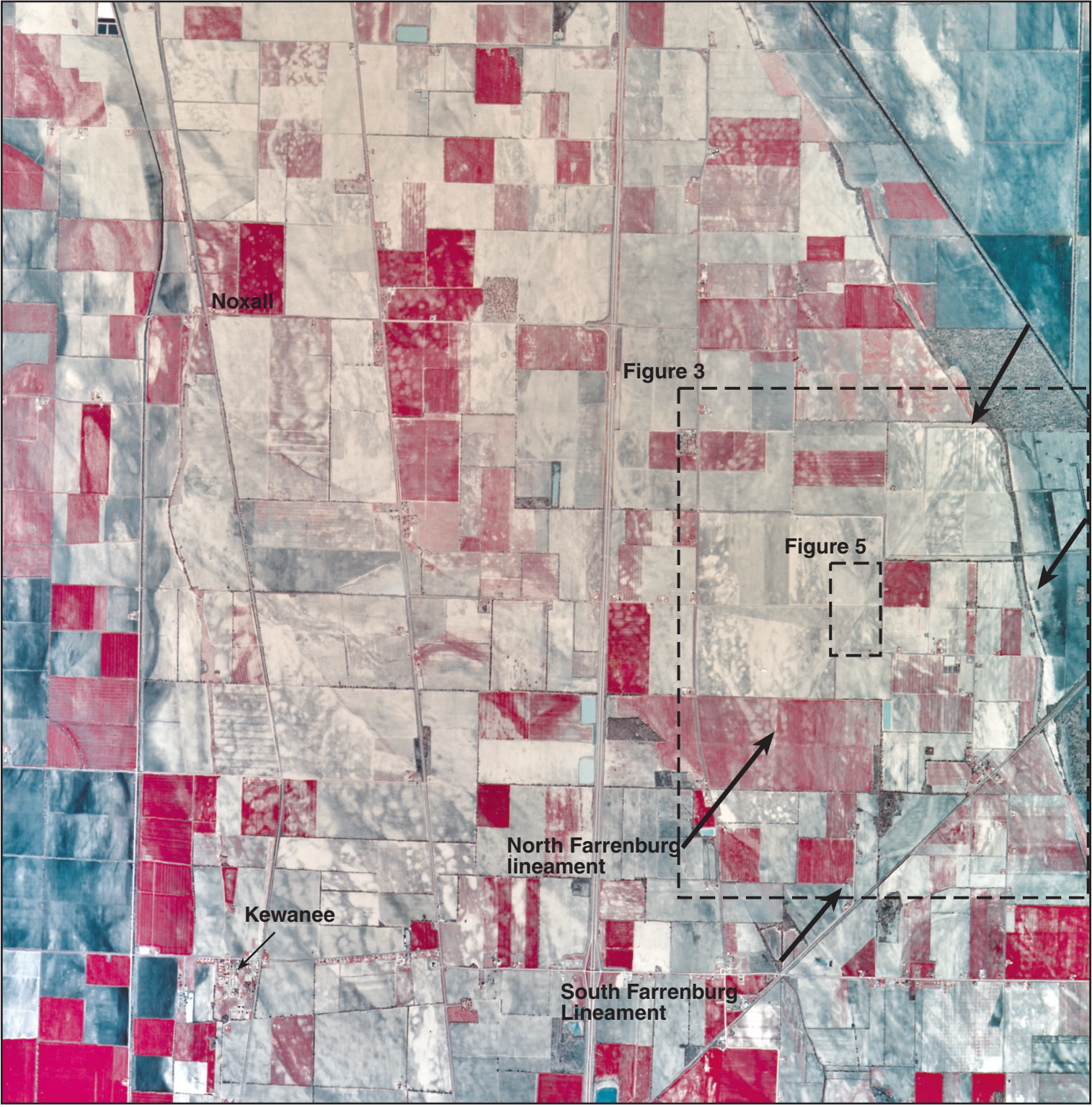
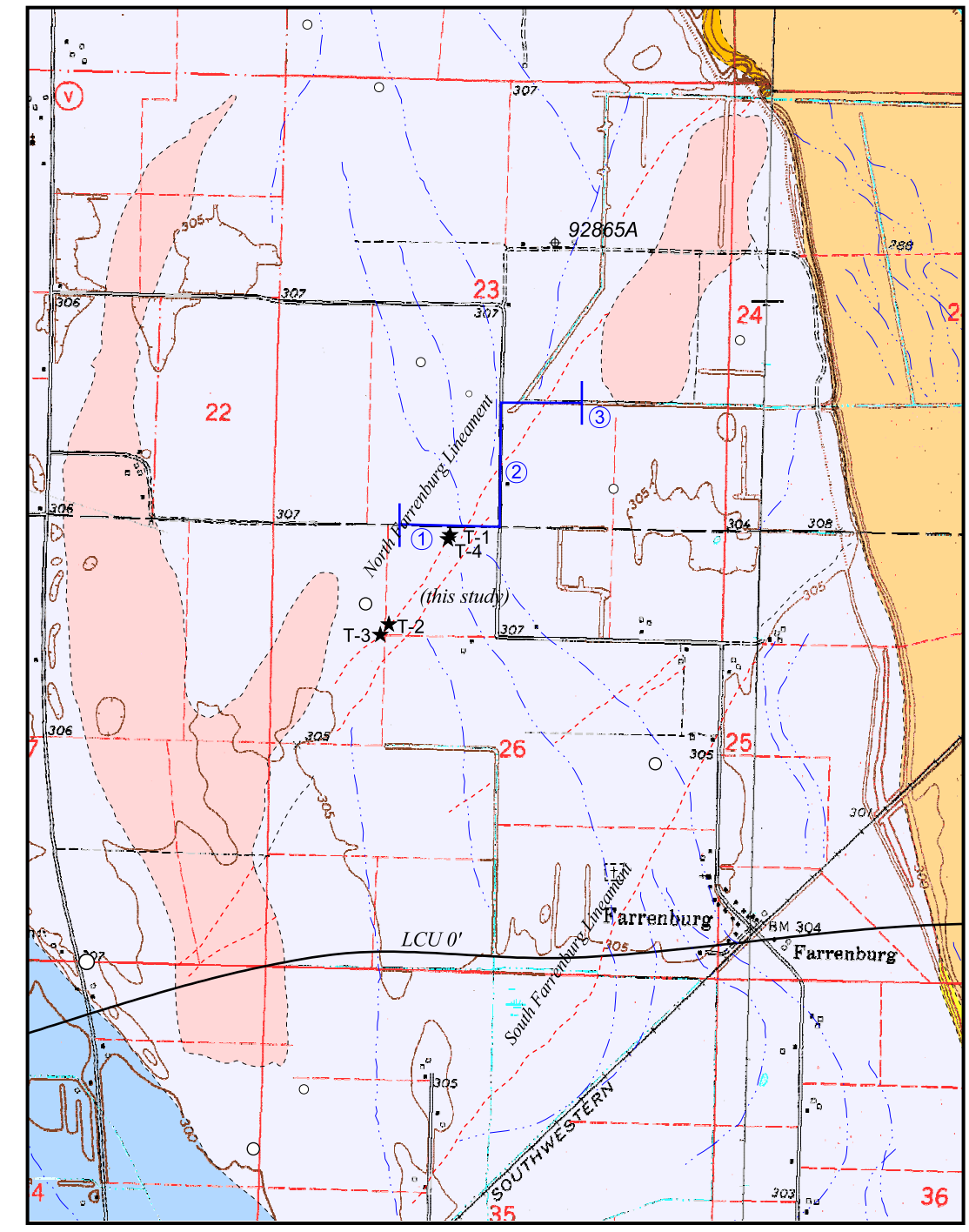


Figure 2. Infrared aerial photograph of Sikeston Ridge showing North and South Farrenburg lineaments. Top of photograph is north. Arrows point to approximate end points of lineaments.



EXPLANATION

- Contact, dashed where approximate, dotted where queried
- Photolineament
- Active drainages
- Paleodrainages
- LCU 5′ — Lake County Uplift (Russ, 1982)

N

SCALE 1:24,000

0 0.5 1 Kilometers

Holocene
- Alluvium
- Colluvium
- Levee

Braided Channel
- Interfluve
- Thebes Gap paleochannel (TG-PC1-undifferentiated)

Sikeston Ridge
- Liquefaction
- Undifferentiated
- Paleochannel four

Previous Studies
- Borehole
- ★T-1 Trench location and designation
- ① S-Wave location and designation

Seismicity (M)
- 0 - 1
- 1 - 2
- 2 - 3
- 3 - 4
- Greater than 4

Figure 3. Site location of North and South Farrenburg lineaments. Surficial geologic mapping from Baldwin et al (1999).

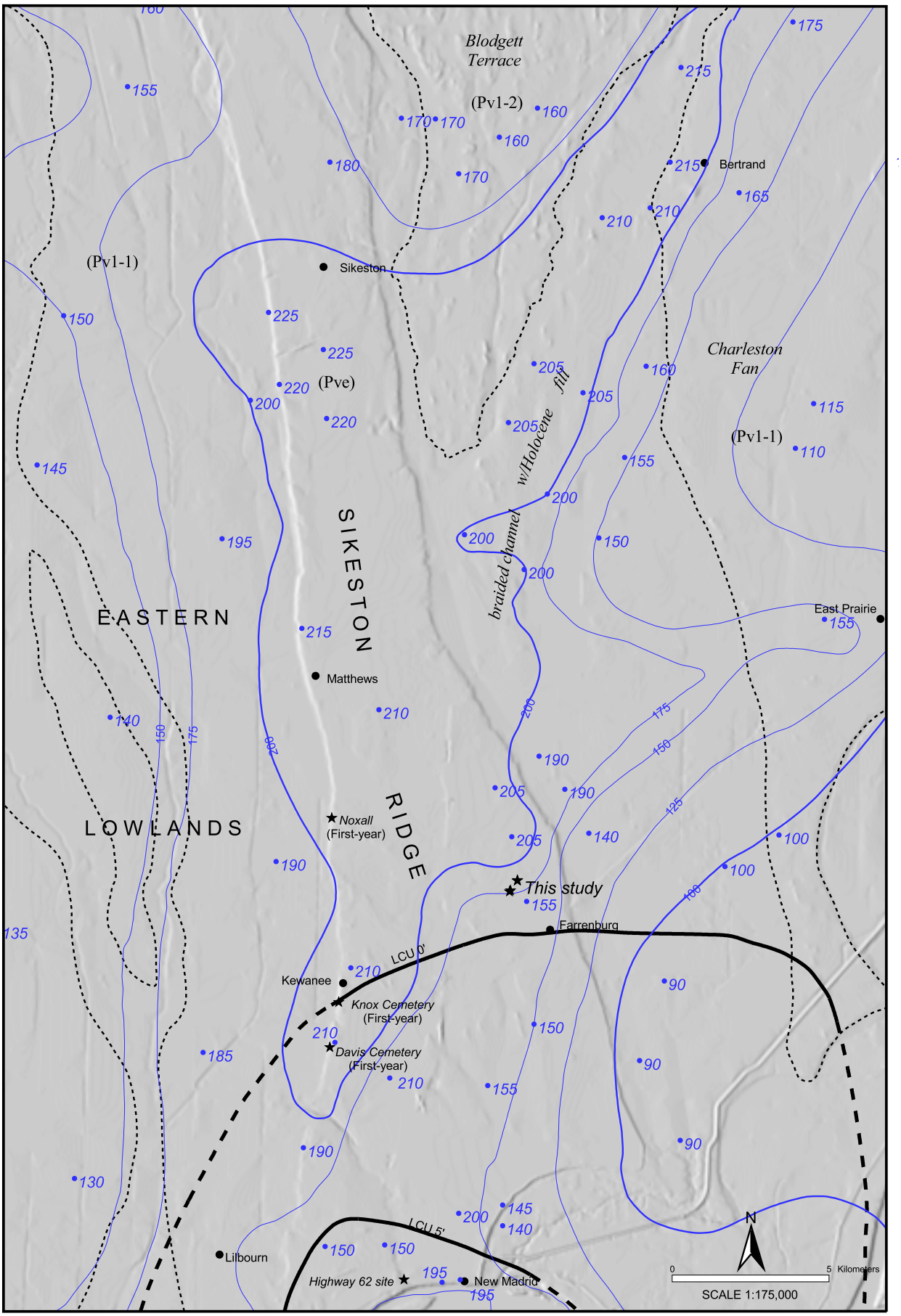


Figure 4. This shaded-relief map shows thickness (in feet) of post-Tetiary alluial deposits from Obermeier, 1989. Note the prominent NE-trending isopach lineament extending from Lilbourn to Bertrand, Missouri. The abbreviations Pve, Pv1-2, Pv1-1 refer to terrace terminology of Saucier (1996). Stars indicate paleoseismic studies on Sikeston Ridge. Vertical exaggeration is 7.5 times.

Seismic-reflection survey

Following the initial identification and mapping of the North Farrenburg lineament, Dr. James Harris conducted a preliminary shallow seismic reflection survey across the lineament (Harris, 2000). Three S-wave (shear wave) seismic reflection profiles totaling about 1 km in length were acquired across the North Farrenburg lineament. Line 1 (360 m long) and Line 3 (290 m long) were oriented east-west, while Line 2 (290 m long) was oriented north-south along New Madrid County Road 707 (Figure 2). All profiles obliquely cross the mapped trace of the North Farrenburg lineament. Preliminary interpretations of the three profiles suggest the possible presence of warped Quaternary deposits and disrupted reflectors in one or all of the seismic profiles (profiles to be shown in final technical report).

Paleoseismic trenching

In October, 2000, four paleoseismic trenches (T-1 to T-4) were excavated and documented across the North Farrenburg lineament to obtain data on the style and timing of surficial deformation associated with the lineament and to assess deformation interpreted from the S-wave profiles (Figure 3). The trench locations were surveyed using a Topcon GRS-303 total station and global positioning satellite equipment (accurate to within 3 m). Stratigraphic and structural relations were flagged, surveyed, and logged at a scale of either 1 in. = 1m or 1 in. = 0.5 m.

Trenches exposed excellent marker beds of late Pleistocene laminated clay, silt and fine to medium-grained sand. Each of the trenches exposed either single or paired liquefaction vents trending between N20°E and N55°E. In addition, trench T-1 and T-4 exposed faulting and soft-sediment deformation of a Pleistocene paleochannel. The near-vertical faults strike N42°E and N30°E in trench T-1 and T-4, respectively. To estimate the timing of deformation and to better constrain the age of Sikeston Ridge, detrital charcoal samples were collected from the paleochannel deposits and sand vents. At least five detrital charcoal samples will be submitted for radiometric dating. It is unclear if the faulting exposed in the trenches is from primary tectonic or secondary tectonic deformation, therefore to help differentiate between the two types of deformation, oriented soil samples from the fault zone and vents were collected for computer-based image analysis (see section below). Interpretation and documentation of trenches T-1 to T-4, coupled with radiocarbon data, will be presented in the final technical report.

Characterization of textures in unconsolidated sand

Dr. Susan Cashman anticipates measuring textural characteristics (grain size, grain shape, grain orientation, grain center-to-center distances) of faulted and unfaulted deposits collected from the trench exposures. Measurements will be made using computer-based image analysis of photomicrographs and scanning electron microscope (SEM) images. The goal of this task is to identify textural characteristics of fault zone sediments that record a signature for coseismic slip events versus secondary deformation (i.e., liquefaction). Application of this technique has been applied to faulted marine terrace sand along the active McKinleyville fault (Cashman and Cashman, 2000) and has

successfully demonstrated that tectonic faulting of semi-consolidated sand is accompanied by compaction, grain rotation and cataclasis.

Aerial reconnaissance

Aerial reconnaissance of the North and South Farrenburg lineaments, including Sikeston Ridge, was conducted to confirm the location and length of the lineaments. The aerial survey demonstrates the presence of the lineaments, and that trenches T-1 to T-4 crossed all or part of the North Farrenburg lineament (Figure 5).

REPORTS PUBLISHED

This project is in progress, thus no publications have been prepared at this time. Results of our study may be useful for both deterministic and probabilistic regional and site earthquake hazard characterizations. The first year of study (Baldwin et al., 2000) is in preparation for a peer-reviewed journal and will be titled: "Sikeston Ridge: Erosional remnant or tectonic fault-bounded block within the New Madrid seismic zone of the central United States?" We expect to complete this paper by early 2001.

It is anticipated that the findings from both the first and second year of study will be presented at the Millennial Meeting of the Seismological Society of America hosted by Stanford University's Earthquake Engineering Center and the United States Geological Survey, Menlo Park Campus in April 2001. We anticipate publishing the second-year results as a short refereed journal article. The surficial geologic map, geophysical profiles, trench logs, and graphic files produced during the second-year study will be incorporated in the final NEHRP technical report, and a peer-reviewed paper.

References

Baldwin, J.N., Barron, A.D., and Kelson, K.I., 2000, First Year Annual Technical Report: The origin and paleoseismic history of Sikeston Ridge, New Madrid Missouri, U.S. Geol. Surv. NEHRP Award No. 99-HQ-GR-0096, 36 p.

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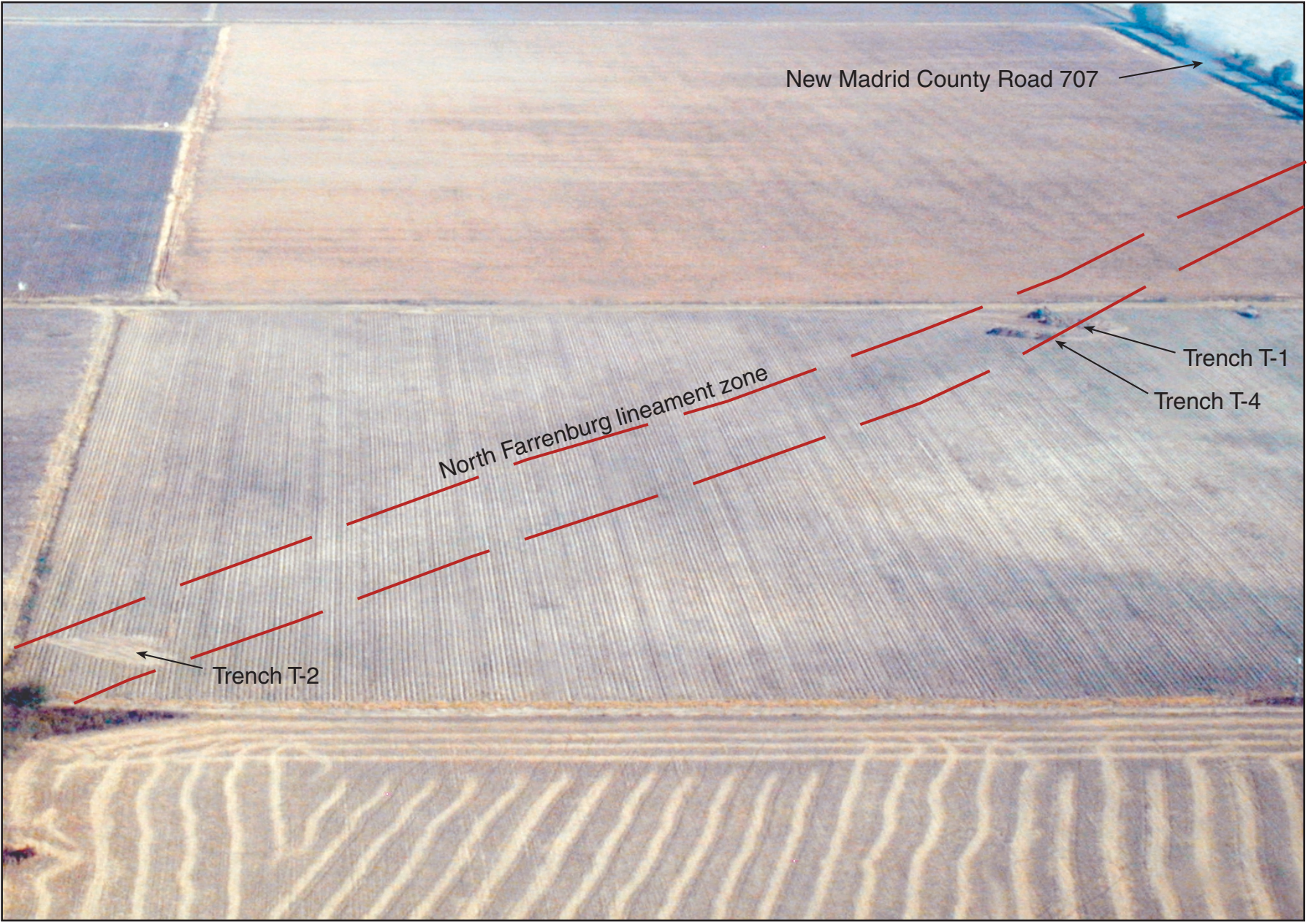

Figure 5. Oblique aerial view looking north shows Farrenburg lineament and trenches T-1, T-2 and T-4. Note that the tonal lineament cuts obliquely from the southwest to the northeast across the fields. Trench T-3 is located directly southeast of vegetation in lower left-hand corner of photograph.

Geophysical and Paleoseismic Investigation along the Farrenburg Lineament-North: Deformation associated with the New Madrid North Fault?

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Non-technical Summary

Understanding the location of seismogenic structures within the New Madrid seismic zone associated with generating large magnitude earthquakes, and their timing, is critical for assessing seismic hazards and calculating probabilities of large earthquakes in the central United States. In this study, we are evaluating a pair of northeast-trending lineaments that , we hypothesize may be associated with the inferred New Madrid North fault (Schweig and Johnston, 1996). The lineaments are aligned in part with contemporary microseismicity, geophysical anomalies, thickness variations of Quaternary deposits, sand vents, and faulting. This is a preliminary investigation to evaluate the Northern Farrenburg lineament for the presence or absence of surface fault rupture, and to collect initial information on the timing and recurrence of past

earthquakes along this lineament. An improved understanding of the earthquake cycle in the New Madrid seismic zone is critical for providing input to probability estimates for future earthquake occurrence, and thus for developing adequate risk mitigation in the central United States.

Reports Published

Because this project is in progress, there have been no publications generated yet. The first year of study (Baldwin et al., 2000) is in preparation for a peer-reviewed journal and will be titled: "Sikeston Ridge: Erosional remnant or tectonic fault-bounded block within the New Madrid seismic zone of the central United States?" We expect to submit this paper in early 2001.

Lastly, the findings from both the first and second year of study will be presented separately at the Millennial Meeting of the Seismological Society America hosted by Stanford University's Earthquake Engineering Center and the United States Geological Survey, Menlo Park Campus in April 2001.

References

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